

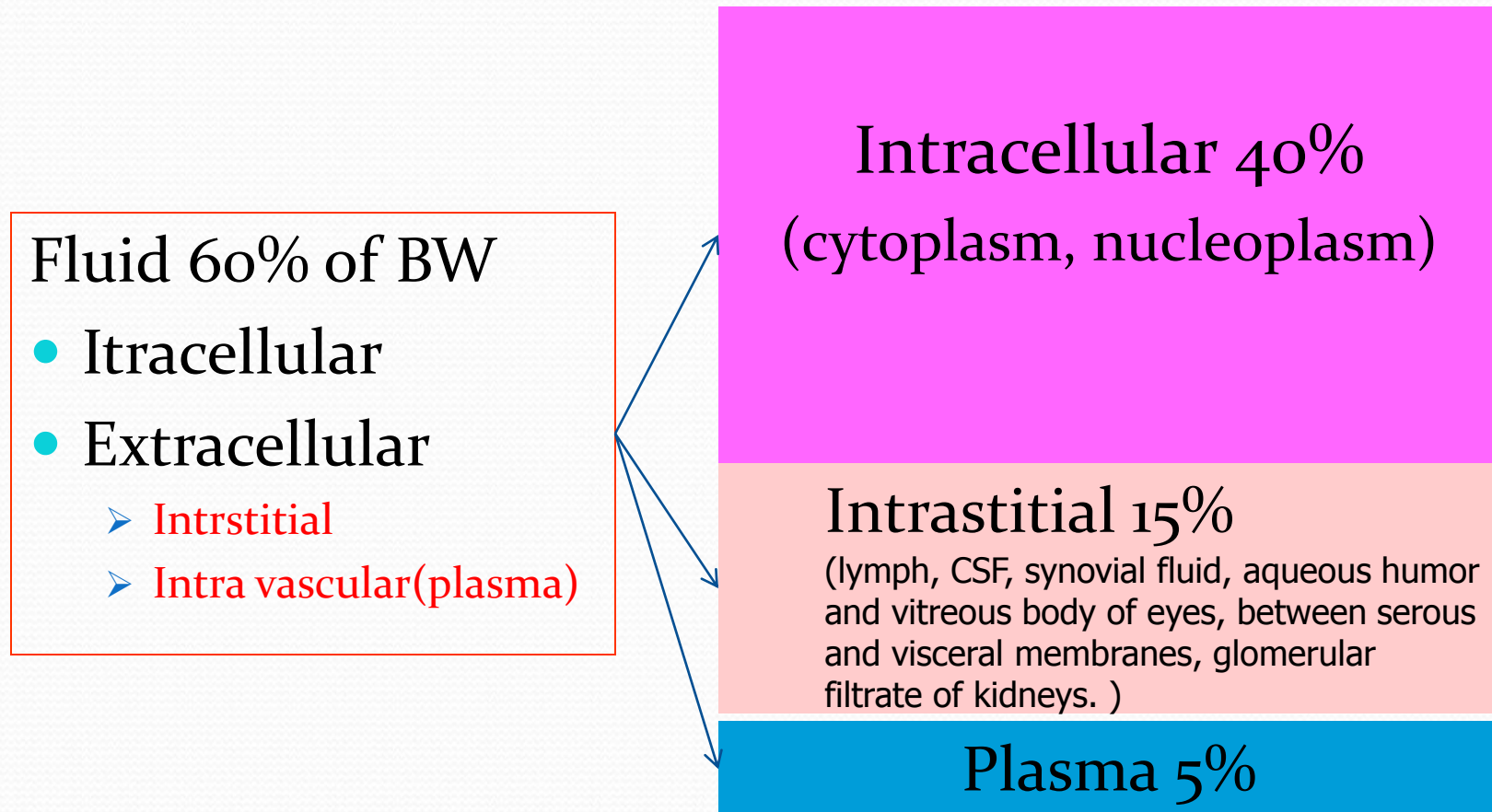


Fluid & Electrolyte balance

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March 4, 2018

Distribution of body fluids (by wt)



There is continuous ongoing equilibrium between the intracellular and extracellular spaces.

Fluid content according to age

- Total body water (TBW) vary with age:
 - Preterm = 80-85%
 - Term = 75%
 - Infant= 65%
 - Older children & adult male= 60%
 - Adult female=50%
- After birth term infants loses approximately 5%-15% of their body weight in the 1st week of life.
- *TBW ↓ to 60% by 1st yr of life*
- *Female has less fluid content because of more fat cells*

Electrolytes composition of body fluids

Electrolytes are measured in mEq or mmol

- ***Cation:***

- Sodium (Na^+) : 135 – 145 mEq/L
- Potassium (K^+) 3.5 – 5.50 mEq/L
- Calcium (Ca^{++}) 8.5 – 10.5 mg/dL
- Ionized Calcium 4.5 – 5.5 mg/dL
- Magnesium (Mg^{++}) 1.5 – 2.5 mEq/L

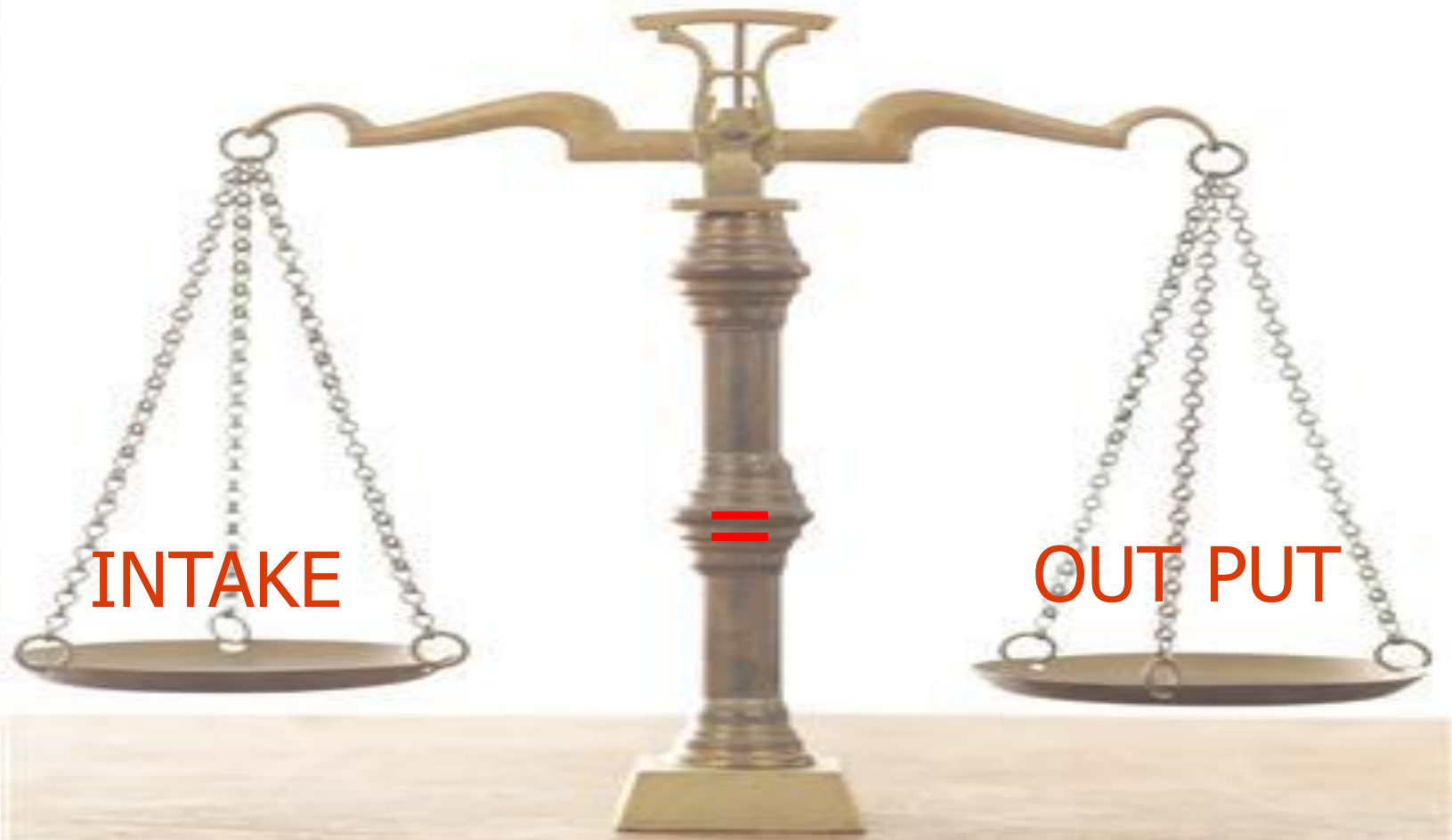
- ***Anion:***

- Bicarbonate (HCO_3^-) 24 – 30 mEq/L
- Chloride (Cl^-) 95 – 105 mEq/L
- Phosphate (PO_4^-) 2.8 – 4.5 mg/dL

CATION	ANION	CATION	ANION
Na ⁺ 140	Cl ⁻ 140	K ⁺ 140	Phos ⁻ 107
	HCO ₃ ⁻ 24		Prot ⁻ 40
K ⁺ 4	Prot ⁻ 14	Na ⁺ 13	HCO ₃ ⁻ 10
Ca ⁺ 2.5	Others 6	Mg ⁺ 17	Cl ⁻ 3
Mg 1.1	PO ₄ - 2		
EXTRA CELLULAR FLUID		INTRA CELLULAR FLUID	

Distribution of Cation and Anion in ECF & ICF (mEq/l)

Fluid & Electrolyte balance?



Daily physiological fluid balance

INTAKE		OUTPUT	
• Ingested liquid:	1500 ml	• Kidney:	1500 ml
• Ingested food:	800 ml	• Skin loss:	600 ml
• Metabolism:	200 ml	• GI:	100 ml
		• Lung	300 ml
Total	2500 ml/day	Total	2500 ml

Daily fluid balance of an adult

How the fluid & electrolytes moves amongst the compartment?

- ICF and ECF maintains osmotic equilibrium because cell membranes are permeable to water
- Fluid & electrolytes moves across the semi permeable membrane by:
 - A. Passive transport
 - B. Active transport

Movement of fluid & electrolytes

A. Passive transport (no energy required):

- **Osmosis**: *Fluid* move from higher concentration to lower concentration
- **Diffusion** = *Molecules* move from higher concentration to lower (Concentration gradient)
- **Filtration** = *Fluid and diffusible substances* move together across a membrane; moving from ↑ pressure to ↓ pressure
- **Hydrostatic pressure** : Fluids moves from an area of higher pressure to area of lower pressure

B. Active transport(energy required):

- Sodium-Potassium Pump

Concentration of Body fluid

- Units of solute concentration are *osmolarity and osmolality*
 - **Osmolarity:** Number of osmoles of solute per liter (L) of solution. It is expressed as osmol/L
e.g 1 mol/L NaCl solution has an osmolarity of 2 osmol/L
 - **Osmolality :** Number of osmoles of solute per kilogram(kg) of solvent. It is expressed as osmol/kg
 - Normal serum osmolality=280-298 mosmol/kg

Clinical relevance of osmolality

Calculation:

- *Serum osmolality (mosmol/kg) =*

$$2(\text{Na}^+ + \text{K}^+) \text{ mmol/l} + \text{Urea (mmol/l)} + \text{Glucose (mmol/l)}$$

- *Effective osmolality(Tonicity):* Osmotic force that is mediating the shift of water between the ECF and the ICF =

$$2 \times \text{Na}^+ \text{ (mmol/l)} + \text{Glucose (mmol/l)}$$

- *The osmotic gap* (osmolal gap): is the difference between the actual osmolality (measured by the laboratory) and the calculated osmolality
- A normal osmolal gap is $< 10 \text{ mOsm/kg}$

Regulation of Body Fluids

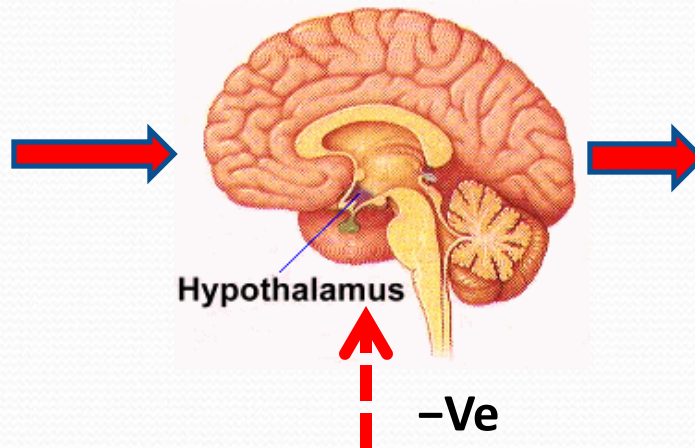
Body fluid Homeostasis is maintained through

- A. Fluid intake
- B. Hormonal regulation
 - 1. *Antidiuretic hormone(ADH)*
 - 2. *Renin-Angiotensin-Aldosterone Mechanism*
 - 3. *Natriuretic Peptides*
- C. Fluid output

A. Fluid intake

Intake is control by hypothalamic thirst center

- ↑ plasma osmolality of 1–2%
- ↓ plasma volume 10%–15%
- Baroreceptor input, angiotensin II, and other stimuli

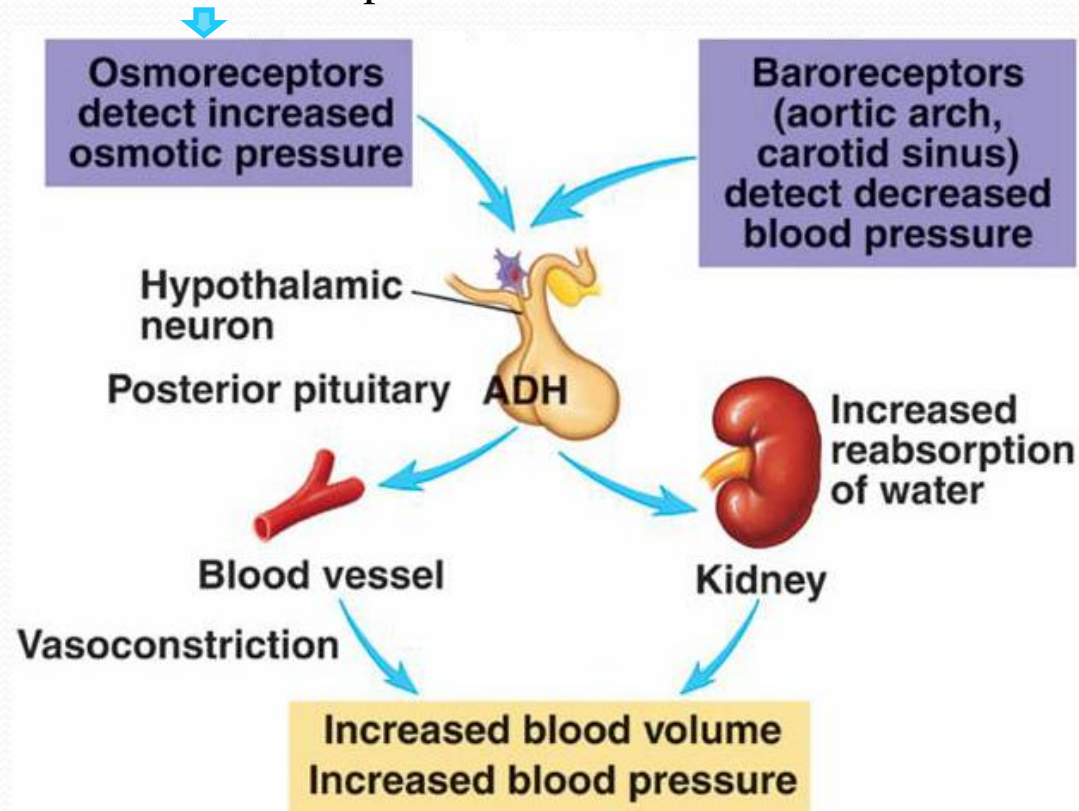


- Moistening of the mucosa of the mouth and throat
- Activation of stomach and intestinal stretch receptors

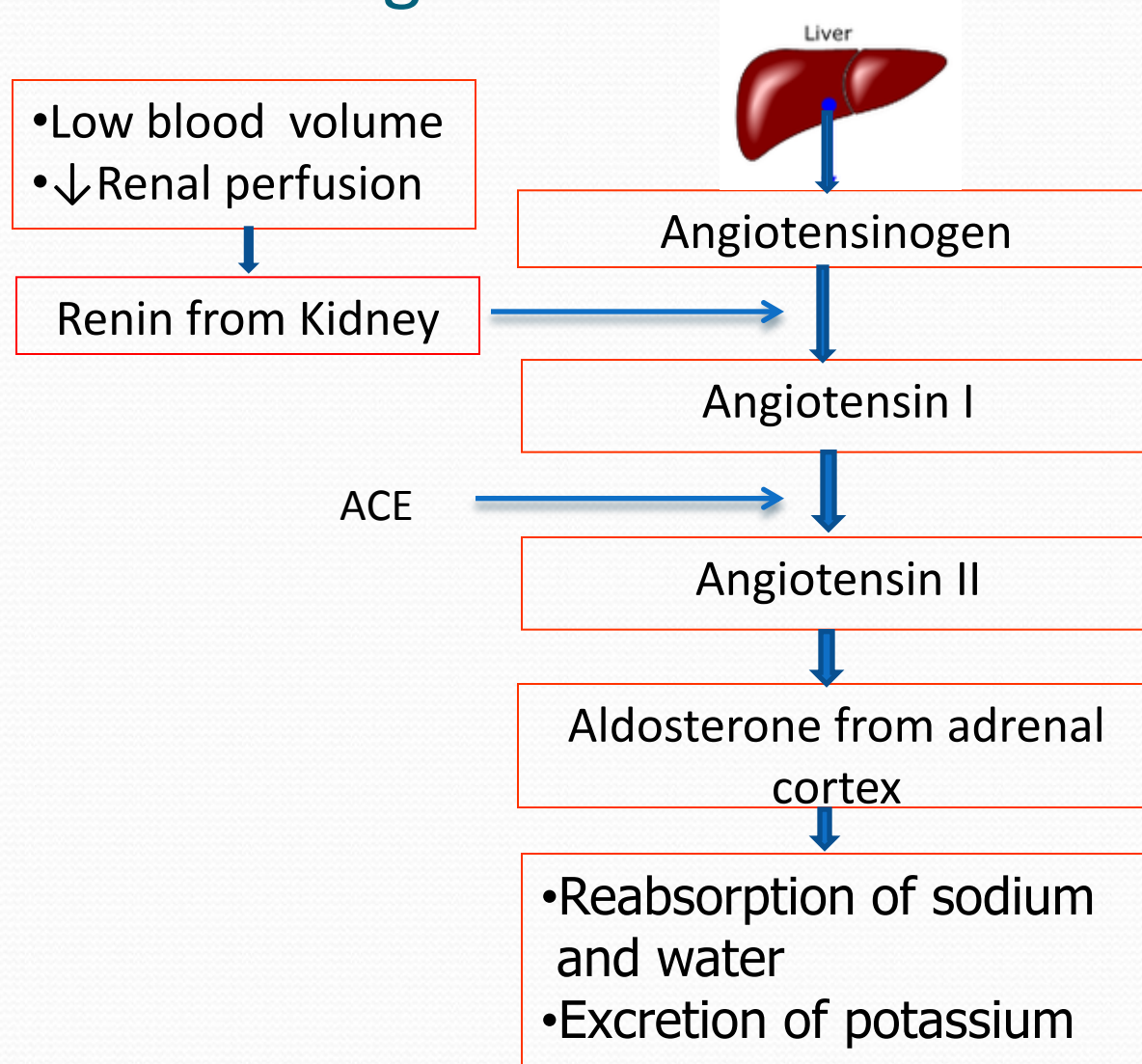
B. Hormonal regulation

1. Antidiuretic hormone(ADH)

- ↓ Fluid volume
- ↑ serum osmolality
- Thrust via osmoreceptor



2. Renin- Angiotensin-Aldosterone Mechanism



3. Natriuretic Peptides

- Natriuretic Peptides
 - Atrial Natriuretic Peptide(ANP) from atria
 - Brain Natriuretic Peptide(BNP) from ventricle
 - Action
 - Acts like a diuretic that causes sodium loss and inhibits the thirst mechanism
 - Inhibit rennin release
 - Inhibit the secretion of ADH and aldosterone
 - Vasodilatation

C. Regulation by fluid output

Daily fluid losses: 2500 ml for an adult

- Kidney(Urine): 55%
- Skin: 30%
- Lung: 10%
- GI (Stool): 2-5%

Renal handling of Fluid & Electrolytes

Substance	Filtered	Excreted	Net reabsorption
Water	180 L	1.5 L	98-99%
Na ⁺	26,000 mmol	100-250 mmol	>99%
Cl ⁻	21,000 mmol	100-250	>99%
K ⁺	800 mmol	40-120 mmol	>85-95%
HCO ₃ ⁻	4,800 mmol	0 mmol	100%
Urea	54 gm	27-32 g	40-50%



Regulation of Electrolytes

Regulation of Sodium & Water

- Major cation in the ECF (N=135 - 145 mEq/L)
- Combines with chloride and bicarbonate to help regulate acid-base balance
- **Recommended daily intake 2.5 gm/day**
- **Kidney regulates sodium balance and is the principal site of sodium excretion**
- **Aldosterone** helps in sodium and water conservation

Potassium regulation

- Major electrolyte and principle cation in the ICF
 - Regulates metabolic activities
 - Required for glycogen deposits in the liver and skeletal muscle
 - *Required for transmission of nerve impulses, normal cardiac conduction and normal smooth and skeletal muscle contraction*
- Daily intake 1-2 mEq/kg
- Regulated by dietary intake and renal excretion
- Intestine absorbs about 90% of ingested potassium
- Regulate by renin-angiotensin-aldosterone mechanism





Fluid & Electrolyte therapy

Fluid therapy

1. ***Maintenance therapy*** : Replacement of daily physiologic losses of water and electrolytes under normal condition
2. ***Deficit therapy***: Replacement of abnormal loss

Maintenance fluid requirement

- In normal physiological condition, children loss water, & electrolytes via urine, stool, skin and lungs.
- **Maintenance fluids replaces these daily physiological losses** and avoid the development of dehydration and deficiencies of electrolytes.
- IV maintenance fluids are needed in a child who cannot be fed/take orally.
- Water requirements are directly related to caloric energy expenditures.
- For expenditure of 1 kcal/kg need 1 ml/kg of water .
- Caloric expenditure varies with the age. Younger the age expends more calories thus loose more water.
- Daily fluid requirement depends on ***weight of the children.***

Maintenance fluid requirement(cont..)

Daily losses:

- **Sensible losses:** 60%
 - Urine: 55%
 - Stool: 5%
- **Insensible losses:** 40%
 - Skin: 30%
 - Lung: 10%

Insensible loss increases in:

- Fever-Increase by 10-12% per 1 °C above 37.8 °C.
- Tachypnea increase loss by 10-30%.
- Prematurity- insensible loss more than term.

Maintenance electrolytes requirement

- Maintenance electrolyte requirements are due to losses, mainly in urine & little amount in sweat and stool
- Daily electrolytes requirement for healthy child:
 - Sodium 2 - 3 mmol/100ml H₂O /day
 - Potassium 1 - 2 mmol/100ml H₂O /day
 - Chloride 2 - 3 mmol/100ml H₂O /day

Maintenance fluid calculation

Holliday-Segar Method for calculating maintenance fluid requirements in children:

Weight	*Daily basis	Hourly basis(4-2-1)
1st 10 kg(wt. 1-10 kg)	100 ml/kg	4 ml/kg/hour
2 nd 10 kg (wt. 11 to 20 kg)	1000 ml+50 ml/kg	40 ml/hr+2 ml/kg/hour
Wt >20 kg up to 80 kg	1500 ml+20 ml/kg	60 ml/hr+1 ml/kg/hour

- Maximum 2400 ml/day.
- Maximum 100 ml/hour

**Holliday MA, Segar WE. The maintenance need for water in parenteral fluid therapy. Pediatrics 1957;19:823-832.*

Example: A 5 yrs old child is admitted for impaired consciousness. He was comatose, not dehydrated. Normal renal function. Vital signs stable. Wt. 25 kg. Outline his fluid management plan.

Fluid requirement daily basis :

First 10 kg: $10 \times 100 = 1000$ ml
2nd 10 kg: 10×50 ml = 500 ml
Rest 5 kg: 5×20 ml/kg = 100 ml
Total = 1600 ml/day.

Fluid requirement hourly basis :

First 10 kg: 40ml/hour = 960ml/day
2nd 10 kg: 20ml/hour = 480 ml/day
Rest 5 kg: 5 ml/hour = 120 ml/day
Total = 1560 ml/day.

Electrolytes requirements:

- Sodium = $16 \times 3 = 48$ mmol/day
- Potassium = $16 \times 2 = 32$ mmol/day

Types of IV fluid available

Types of IVF used:

- Normal saline (0.9% NaCl/L) = 154 mEq Na⁺/L
- One-half NS (0.45% NaCl/L) = 77 mEq Na⁺/L
- One-third NS (0.33% NaCl/L) = 57 mEq Na⁺/L
- One-quarter NS (0.25% NaCl/L) = 38 mEq Na⁺/L
- One fifth NS(0.18% Nacl) = 30 mmol/L
- Ringer's lactate= Na⁺ 130 mmol/l, K⁺ 4 mmol/l, Cl⁻ 109 mmol/l, bicarb 28 mmol/l , and Ca⁺⁺ 3 mg/dl)

What types of IV fluid ?

- Child's electrolyte requirement- Na^+ 48 mEq/day & K^+ 32 mEq/day
- Maintenance fluid for the child wt 25 kg-D5W $\frac{1}{2}$ NS with 20 mEq potassium/liter will be adequate
- Recent concerned about using hypotonic solution for long time because of hypernatremia.
- Isotonic fluid should be used specially post operative patients to avoid hyponatremia



Fluid Imbalance

- Dehydration
- Hypovolemia
- Hypervolemia
- Water intoxication

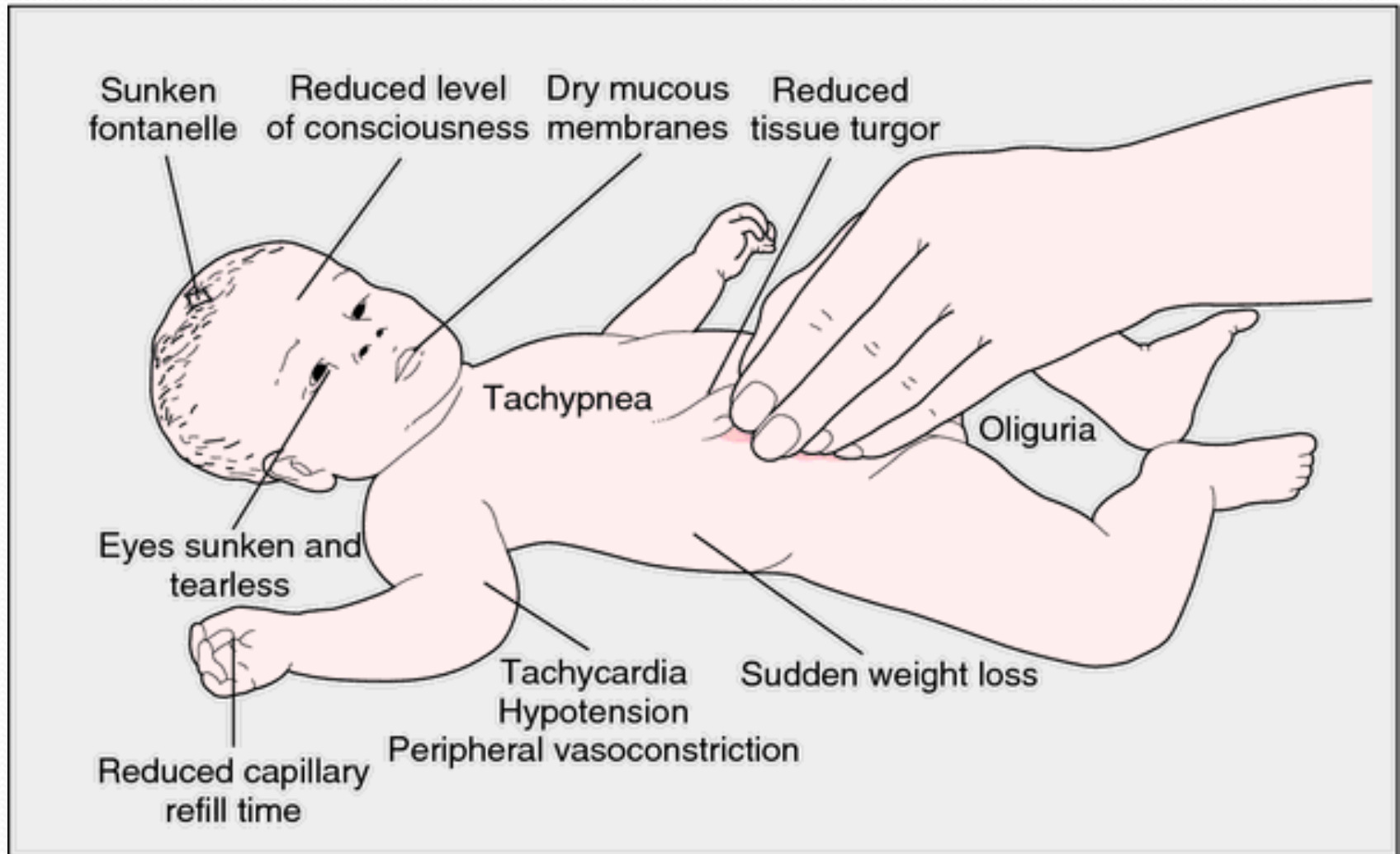
Dehydration

- Abnormal fluid loss causes fluid deficit called **dehydration**
- Conditions can lead to dehydration:
 - Skin: **Fever, under heater, heat exhaustion, burn**
 - GI: **Gastroenteritis**, fistula, intestinal obstruction
 - Lung: **Tachypnea**
 - Kidney: **Polyuria e.g. diabetes**
 - Miscellaneous: Surgical drain, third spacing

Severity of dehydration

- Degree of dehydration can be determined by either
 - Calculating the difference between pre illness weight and present weight.
 - Or by evaluating clinical signs & symptoms of dehydrations.
- According to severity:
 - Mild dehydration -3-5% loss of BW
 - Moderate dehydration-6-9% loss of BW
 - Severe dehydration- $\geq 10\%$ loss of BW

Clinical features of dehydration



Signs & Symptoms	MILD	MODERATE	SEVERE
Wt Loss	3-5%	6-9%	>10%
General condition*	Well, alert	Irritable	Lethargic/floppy
Thirst*	Thirsty	Drinks eagerly	Unable to drink
Oral mucous*	Slightly dry	Dry	Parched
Ant fontanel*	Normal	Depressed+	Depressed ++
Eyes*	Normal	Sunken +	Sunken ++
Skin turgor*	Normal	Decrease	Tenting
Skin pinch retracts:	Normally	in >2 sec	Takes>3 sec
Urine output	Normal	Decrease	No urine
Pulse	Normal	Rapid	Rapid & weak
Respiration	Normal	Deep	Deep & Rapid
BP	Normal	Normal	Decrease
Capillary refill time	Normal	± 2 Sec	> 3 sec

Table. Clinical assessment of severity of dehydration

Types of dehydration

- Once degree of dehydration is calculated, types of dehydration should be determined by measuring serum sodium concentration.
- According to serum Sodium (Na) concentration there are 3 types:
 - Isotonic(Isonatremic)= S. Na 135-150 mmol/l
 - Hypotonic(Hyponatremic)= S. Na <135 mmol/l
 - Hypertonic(Hypernatremic)= S. Na >150 mmol/l

Management of dehydration

- Fluid therapy
 - Enteral
 - Oral rehydration therapy
 - By NGT
 - Parenteral e.g. IV

Oral rehydration therapy (ORT)

Indication:

- Mild & moderate dehydration due to gastroenteritis.

Relative Contra indication:

- Shock
- Altered mental status
- Severe dehydration
- Parental limitations
- Excessive vomiting
- Abdominal distention or absent bowel sounds

Oral rehydration therapy

Preparation of ORS

- ORS supplied in sachet in powder form or in readymade form
- One sachet of ORS should be mixed in 1 liter of health water
- Personal hygiene should be maintained during preparation
- For young children prepared solution are available.



Composition of different types of ORS & other solution

Solution	Glucose Mmol/l	Na Mmol/l	Cl Mmol/l	K Mmol/l	HCO₃ Mmol/l	Osmola lity
WHO 1975	111	90	80	20	30	310
WHO 2002	75	75	65	20	30	245
Pedialyte	140	45	35	20	30	250
Rehydrate	140	75	65	20	30	310
Cola	700	2	2	0	13	750
Apple juice	690	3		32	0	730

Oral rehydration therapy (ORT)

ORT is divided into 2 phases:

- A. **Rehydration phase**: aims to restore the existing deficit fluid
- B. **Maintenance phase**: compensate for continued fluid loss

Golden rule:

“Give them as much as they will drink”

Oral rehydration therapy(cont..)

- A. **Rehydration phase:** Replacement of existing deficit
- Deficit is calculated according to severity of dehydration:
 - Mild dehydration – 50 ml/kg
 - Moderate dehydration – 70 ml/kg.
 - Calculated deficit should be given over 4-6 hour by small and frequent feed by spoon.
 - Additional ORS is given to replace ongoing gastrointestinal losses e.g. Diarrhea or vomiting

Oral rehydration therapy (cont..)

B. Maintenance phase :

- Feeding should be started after rehydration phase.
- Replacement of fluid for continued loss until diarrhea stops;
 - 1 mL of ORS should be replace for each gram of diarrheal stool
 - **Mild diarrhea (≤ 1 stool every 2 hours):** ORS –10 ml/kg/motion until diarrhea stops
 - **Severe diarrhea (> 1 stool every 2 hours):**
 - Need hospital supervision.
 - Replacement of fluid:
 - If stool can not be measure- 10 ml/kg/motion.
 - If stool can not be measure- 10-15 ml/kg/hour.
 - If vomiting: 2 mL/kg for each episode of vomiting.

Management of dehydration

Parenteral therapy

Indications

- Severe dehydration
- Persistent vomiting
- Unable to take orally
- Intestinal surgery
- Paralytic Ileus

Parenteral therapy

Shock therapy:

- To be given in severe dehydration.
- Goal is to expand the intravascular fluid volume rapidly to save the vital organs.
- Isotonic solutions are used e.g. N. saline, ringer lactate, albumin, plasma:
 - *Normal Saline– 20 ml/kg IV bolus rapidly over 20-30 minute*
 - *Repeat bolus until patient is hemodynamically stable.*
 - *This phase of therapy is same for all types of dehydration*

Parenteral therapy (cont..)

Subsequent therapy:

- Depends upon types of dehydration:

1. **Isotonic & hypotonic dehydration:**

- Calculated deficit should be replaced over 24 hours
- Fluid given in initial phase is to be deducted from the calculated deficit
- Calculate maintenance requirement for 24 hour
- Calculate Na^+ & K^+ deficit & choose appropriate fluid
- Half of the deficit + maintenance requirement should be given over 8 hours
- Remaining half to be infused over 16 hours

Fluid & electrolyte calculation in dehydration

Water deficit= Wt X % of dehydration

- In mild dehydration deficit= 50 ml/kg

$$(1\text{kg}=1000\text{ ml}; 5\%= \frac{5 \times 1000}{100} = 50\text{ml/kg})$$

- In moderate dehydration deficit = 60-90 ml/kg
- In severe dehydration deficit ≥ 100 ml/kg

Electrolyte deficit In dehydration;

- Na & Cl deficit=water deficit X 8 mmol/100ml
- K deficit= water deficit X 3 mmol/100 ml

Example:

1 yr old child wt 10 kg arrived in ER with H/O GE since 3 days.
O/E: severely dehydrated, lethargic, HR 180/min, capillary refill time 4+ sec.

Shock therapy:

- $10 \times 20 = 200$ ml of normal saline should be given over 20- 30 min as shock therapy

Serum sodium was 138 mmol/l

Subsequent therapy:

- Deficit fluid = $10 \times 100 = 1000$ ml
- Fluid given during shock therapy = 200 ml
- Remaining fluid deficit = $1000 - 200 = 800$ ml
- Maintenance fluid for 24 hour = $10 \times 100 = 1000$ ml
- Total fluid for 24 hour = $800 \text{ ml} + 1000 \text{ ml} = 1800$ ml
- One half of total fluid = 900ml to be given over 8 hour
- Other half = 900ml to be infused over 16 hour.

Parenteral therapy(cont..)

Choice of fluid:

- Na requirement:
 - Deficit = $8 \text{ mmol}/100\text{ml} = 8 \times 8 = 64 \text{ mmol}$
 - Maintenance = $3 \text{ mmol}/100\text{ml} = 10 \times 3 = 30 \text{ mmol}$
 - Total = $64 + 30 = 94 \text{ mmol/day}$
- Potassium
 - Deficit = $3 \times 10 = 30 \text{ mmol}$
 - Maintenance $1 \times 10 = 10$
 - Total requirement = $30 + 10 = 40 \text{ mmol/day}$
- One half NS in D5W + 20-30 mmol of KCL/l will be appropriate solution.

Parenteral therapy

Subsequent therapy (Cont..)

2. **Hypernatremic dehydration:** $S\ Na^+ > 160\text{mmol/l}$

- Initial phase of therapy is same
- Deficit therapy should be spread over 36-84 hours according to the result of serum Na:
 - Serum Na 145-157 mmol/l- over 24 hr
 - Serum Na 158-170 mmol/l- over 48 hr
 - Serum Na 171-183 mmol/l over 72 hr
 - Serum Na 184-196 mmol/l over 84 hr
- Goal is to decrease serum sodium 12 mmol/24hr

Example:

One yr. old child, wt 10 kg, presented in ER with diarrhea and vomiting for 3 days. O/E child was severely dehydrated, lethargic, HR 180/min, Capillary refill time 5 sec, BP 80/60 mmHg.

- Shock therapy: $20 \times 10 = 200$ ml N S to be given over 30 min
- U & E's result shows S. Na 170 mmol/l.
- Subsequent therapy:
 - Deficit = $10 \times 100 = 1000$ ml
 - Fluid given during initial phase = 200 ml
 - Remaining deficit $1000 - 200 = 800$ ml
 - Maintenance requirement for 48 hr = $(10 \times 100) \times 2 = 2000$ ml
- Total fluid $2000 + 800 = 2800$ ml to be given over 48 hr
- NS or $\frac{1}{2}$ NS D₅W+ KCL should be use

Parenteral therapy(cont..)

Replacement of ongoing losses:

- Can be given IV or orally
- Any abnormal losses should be replace ml for ml
- Losses from the previous hours should be calculated and should be replaced over next same duration
- If stool quantity cannot be measure; 10 ml/kg/ per motion in previous 8 hours & should be replaced over next 8 hours.
- Losses should be replaced every 1-6 hours depending on the rate of loss:
 - NG losses should be replaced 1-4 hourly,



Electrolyte Imbalances

- Hyponatremia/ hypernatremia
- Hypokalemia/ Hyperkalemia
- Hypomagnesemia/ Hypermagnesemia
- Hypocalcemia/ Hypercalcemia
- Hypophosphatemia/ Hyperphosphatemia
- Hypochloremia/ Hyperchloremia

Hyponatremia

- Serum Na⁺ level < 135 mEq/L
 - Mild: 130-134 mmol/L
 - Moderate: 125-129 mmol/L
 - Severe: <125 mmol/L

Hyponatremia

CAUSES:

- **Hypovolemia:**
 - **Diarrhea, vomiting, Excess Sweat,**
 - 3rd spacing: **trauma, burns, pancreatitis**
 - **Diuretics,** Mineralocorticoid deficiency,
 - **Cerebral salt wasting,**
 - Proximal type II RTA
- **Euvolemia:**
 - **SIADH,** Glucocorticoid deficiency, Hypothyroidism,
 - Psychogenic polydipsia,
 - Drugs: **desmopressin,** psychoactive agents,
- **Hypervolemia:**
 - **Acute or chronic renal failure**
 - Congestive heart failure, Cirrhosis/hepatic failure, Nephrotic syndrome

Signs & Symptoms

- Primarily neurologic symptoms:
 - Mild to moderate hyponatremia: Headache, Nausea, vomiting, muscle twitching,
 - Severe Hyponatremia: altered mental status, stupor, seizures, coma
- Hypovolemia - poor skin turgor, tachycardia, decreased BP, orthostatic hypotension
- Hypervolemia - edema, hypertension, weight gain, bounding tachycardia

Management

- Mild Hyponatremia
 - IV 0.9% sodium chloride and/or increased oral Na⁺ intake for hypovolemic hyponatremia
 - Restrict fluid intake for hyper/isovolemic hyponatremia like SIADH
- Severe Hyponatremia
 - Diuretics like furosemide to remove excess fluid
 - Severe symptomatic (Serum Na<120 mmol/l): Infuse hypertonic NaCl solution (1.5%, 3% or 5% NaCl)

Syndrome of Inappropriate Antidiuretic hormone secretion(SIADH)

- **Causes:** Intracranial pathology, post-operative, malignancy, neck surgery, pulmonary pathology, Drugs
- **Diagnosis:**
 - Patient should be euvolemic
 - Investigations: Serum: low Na, low Bun, Normal K, Low uric acid, **Low Serum osmolality**
 - **Urine:** Urine osmolality elevated >100 mOsmol/kg
 - Urine output will be low & urine Na will be elevated

SIADH

Treatment

- Treatment of the underlying disease.
- Fluid restriction to 30-50% maintenance.
- Avoid excess free water.
- Administration of oral or intravenous sodium chloride.
- Loop diuretics e.g. Furosemide.
- Severe symptomatic hyponatremia ($S \leq Na\ 120$); IV 1.5% or 3% NS.
- Renal V-2 vasopressin receptor antagonists—called *vaptans*

Hypernatremia

- Excess Na^+ relative to body water
- Serum sodium $>155 \text{ mEq/l}$
- Causes:
 - Excess water losses: Gastroenteritis
 - Urinary water loss: Diabetes insipidus, osmotic diuresis
 - Over-ingestion of Na^+ , Salt poisoning
 - Iatrogenic- Infusion of sodium bicarbonate or hypertonic saline

Signs & Symptoms

- Flushed skin, agitation, low grade fever, thirst
- Neurological symptoms; irritable, restless, weak, and lethargic
- Severe symptoms are observed with an acute rise of sodium above 160 mEq/L includes altered mental status, lethargy, coma, and seizures.
- Signs of hypovolemia in case of dehydration
- Signs of dehydration is not obvious in hypernatremic dehydration

Management

- Correct underlying disorder
- Gradual fluid replacement over 36-48 hour in case of *hypernatremic dehydration by isotonic fluid*
- In cases where hypernatremia alone like DI, therapy is aimed at correcting the plasma sodium by providing free water
- Monitor for signs & symptoms of cerebral edema
- Monitor serum Na⁺ level
- Seizure precautions

Hyperkalemia

- ***Serum K^+ > 5.5 mEq/L***
 - Mild: S K^+ 5.5-6.5 mEq/L
 - Moderate : S K^+ 6.5-8.00mEq/L
 - Severe: S K^+ >8 mEq/L
- **Cause**
 - Altered kidney function,
 - Increased intake (salt substitutes),
 - Blood transfusions,
 - Medication (K^+ -sparing diuretics),
 - Cell death (trauma)

Signs & symptoms

- Irritability
- Paresthesia
- Nausea, abdominal cramps, diarrhea
- Muscle weakness (especially legs)
- Hypotension
- Arrhythmia
- *ECG changes:*
 - *Prolong PR interval, tented T wave, wide QRS complex, absent P, Asystole, VF.*

Management of hyperkalemia

- Treat the underlying cause
- Confirm by repeat analysis, ECG
- Mild hyperkalemia:
 - Remove all sources of potassium
 - Loop diuretics (Lasix)

Management of hyperkalemia(cont..)

Moderate & Severe Hyperkalemia: Above management +

- *protect from cardiac effects potassium:* IV 10% calcium gluconate infusion.
- *Enhancement of cellular uptake of potassium:*
 - IV Sodium bicarbonate .
 - β_2 agonist(Salbutamol, Nebulized or IV).
 - **Glucose** 0.5 gram/kg + **Insulin** 0.3 units/gm of glucose infusion.
- *Enhancement of total body potassium elimination:*
 - Resonium, PO/PR (Calcium Polystyrene Sulphonate).
 - Dialysis in case of refractory hyperkalemia.

Hypokalemia

Serum K^+ < 3.5 mEq/L

Can be caused by

- Severe GI losses from vomiting and diarrhea including congenital chloride diarrhea.
- Prolonged diuretic use
- Inadequate potassium intake
- Laxative use
- Diabetic ketoacidosis
- Dialysis and diuretic therapy

Signs & Symptoms

- Muscle weakness
- Constipation, ileus
- Irregular, weak pulse, Palpitations
- Nausea or vomiting
- Abdominal cramping
- Polyuria, nocturia, or polydipsia
- Psychosis, Depression, delirium, or hallucinations
- Orthostatic hypotension
- Numbness (paresthesias) Paralysis,
- EKG changes:
 - Ventricular dysrhythmia,
 - Prolongation of QT interval
 - ST-segment depression, T-wave flattening, Appearance of U waves

Management

- Increase dietary K^+
- Oral potassium chloride supplements
- Add K^+ replacement if receiving IV fluid
- Change or add K^+ sparing diuretic if receiving diuretic medication
- Monitor EKG changes

Hypocalcemia

- Corrected Serum calcium < 8.5 mg/dl (<2.1 mmol/L)
- Ionized calcium level < 4.5 mg/dl (1 mmol/l)
- ↓ of 1 gm/dl of serum albumin, there is decrease of 0.8mg/dl (0.2 mmol/l) of total serum calcium
- *Corrected calcium (mg/dL) =*
Measured total Ca (mg/dL) + 0.8 (40.0 – serum albumin [g/dL])*
** 40.0 represents the average albumin level gm/dl*
- Causes:
 - inadequate intake, nutritional ricket
 - malabsorption, pancreatitis,
 - Hypoparathyroidism (Congenital or aquired),
 - loop diuretics,
 - low magnesium levels

Signs & Symptoms

- Neuromuscular
 - Anxiety, confusion, irritability, muscle twitching, paresthesias (mouth, fingers, toes), tetany
- Fractures
- Diarrhea
- EKG changes

Management

- Calcium gluconate IV for acute symptomatic cases
- Oral or IV calcium replacement
- Vit D replacement in case of Ricket
- Cardiac monitoring



Thanks for attention.
Question?